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Anderson et al.

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(54) **METHODS FOR FORMING CONNNECTORIZED FIBER OPTIC CABLING**

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G02B 6/44	(2006.01)
G02B 6/38	(2006.01)

(52) **U.S. Cl.**

CPC ***G02B 6/3834*** (2013.01); ***G02B 6/3861*** (2013.01); ***G02B 6/3885*** (2013.01); ***G02B 6/3887*** (2013.01); ***G02B 6/3898*** (2013.01)

(58) **Field of Classification Search**

CPC .. G02B 6/3885; G02B 6/3887; G02B 6/3834; G02B 6/3898; G02B 6/3861

USPC 385/55, 56, 58–60, 62, 66, 68, 69, 385/75–78, 81, 84, 86, 87, 100, 109, 113

See application file for complete search history.

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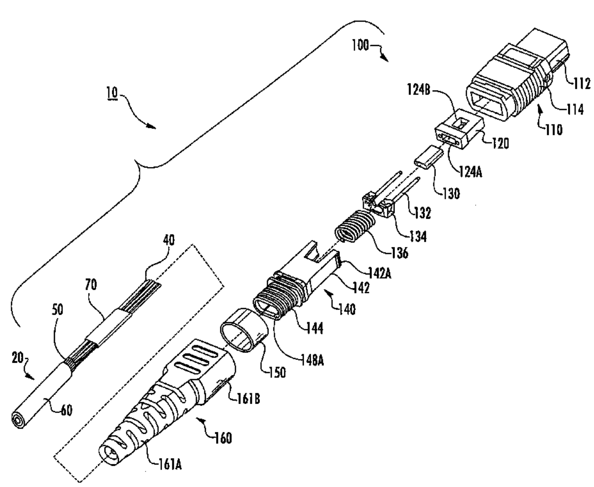
(57) **ABSTRACT**

A connectorized fiber optic cabling assembly includes a loose tube fiber optic cable and a connector assembly. The cable has a termination end and includes: an optical fiber bundle including a plurality of optical fibers; at least one strength member; and a jacket surrounding the optical fiber bundle and the at least one strength member. The connector assembly includes a rigid portion and defines a fiber passage. The connector assembly is mounted on the termination end of the cable such that the optical fiber bundle extends through at least a portion of the fiber passage. The plurality of optical fibers of the optical fiber bundle have a ribbonized configuration in the rigid portion of the connector assembly and a loose, non-ribbonized configuration outside the rigid portion. The plurality of optical fibers undergo a transition from the ribbonized configuration to the loose, non-ribbonized configuration in the rigid portion of the connector assembly. According to some embodiments, the rigid portion of the connector assembly includes a rigid connector housing.

16 Claims, 16 Drawing Sheets



Related U.S. Application Data

is a continuation of application No. 11/438,647, filed on May 22, 2006, now Pat. No. 7,537,393.

(60) Provisional application No. 60/688,492, filed on Jun. 8, 2005, provisional application No. 60/688,493, filed on Jun. 8, 2005.

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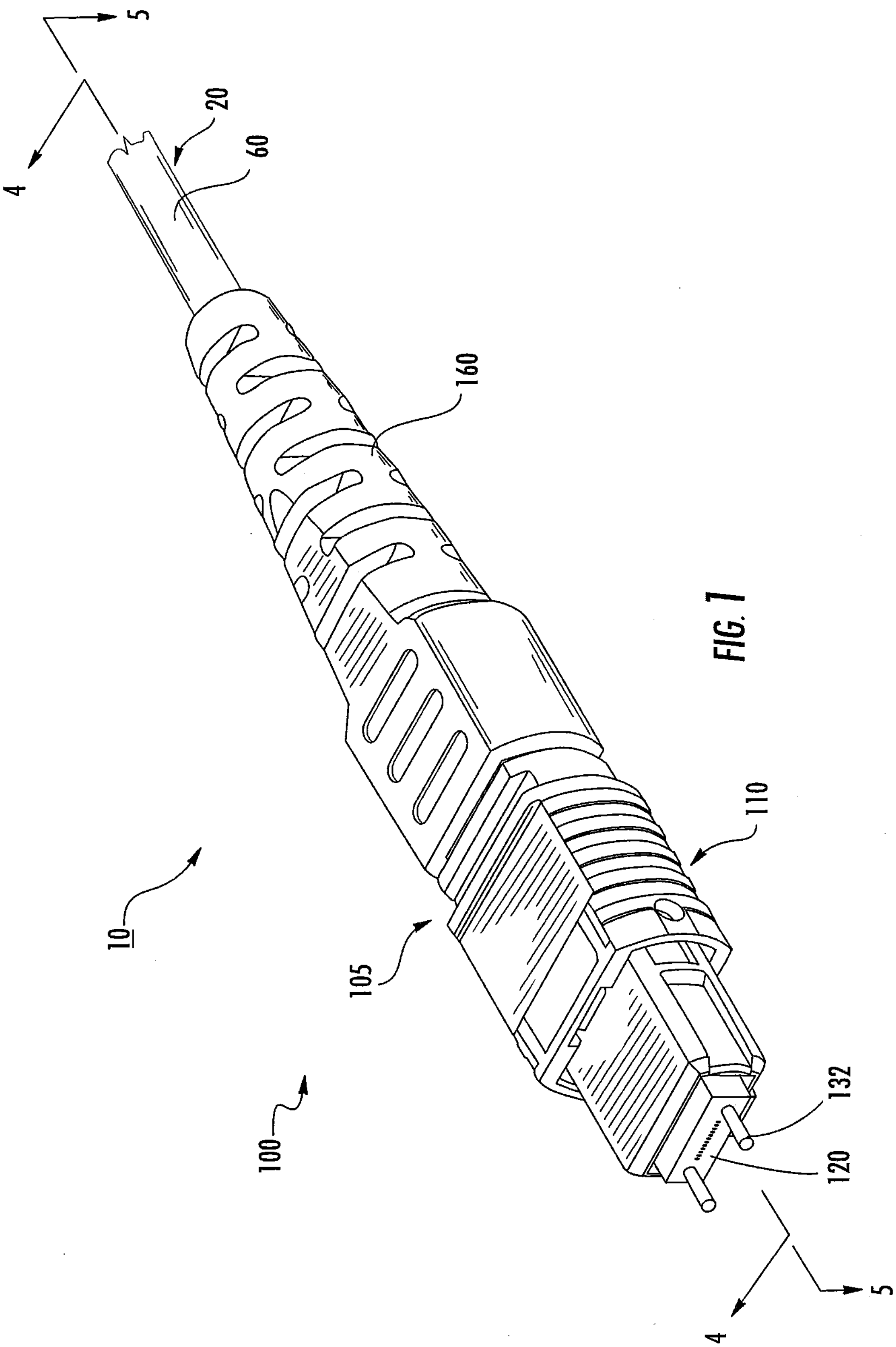
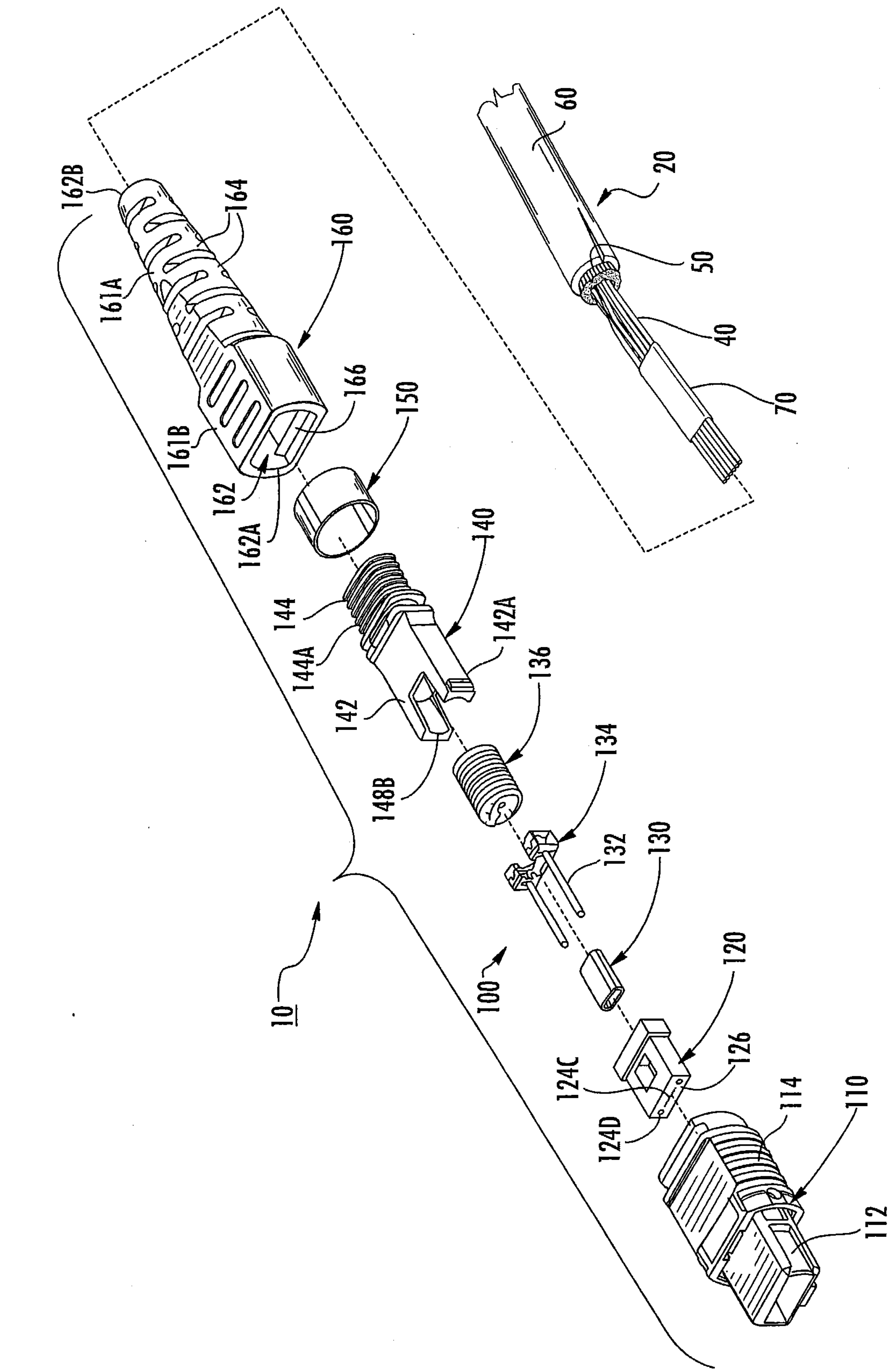


FIG. 1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124D
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FIG. 2

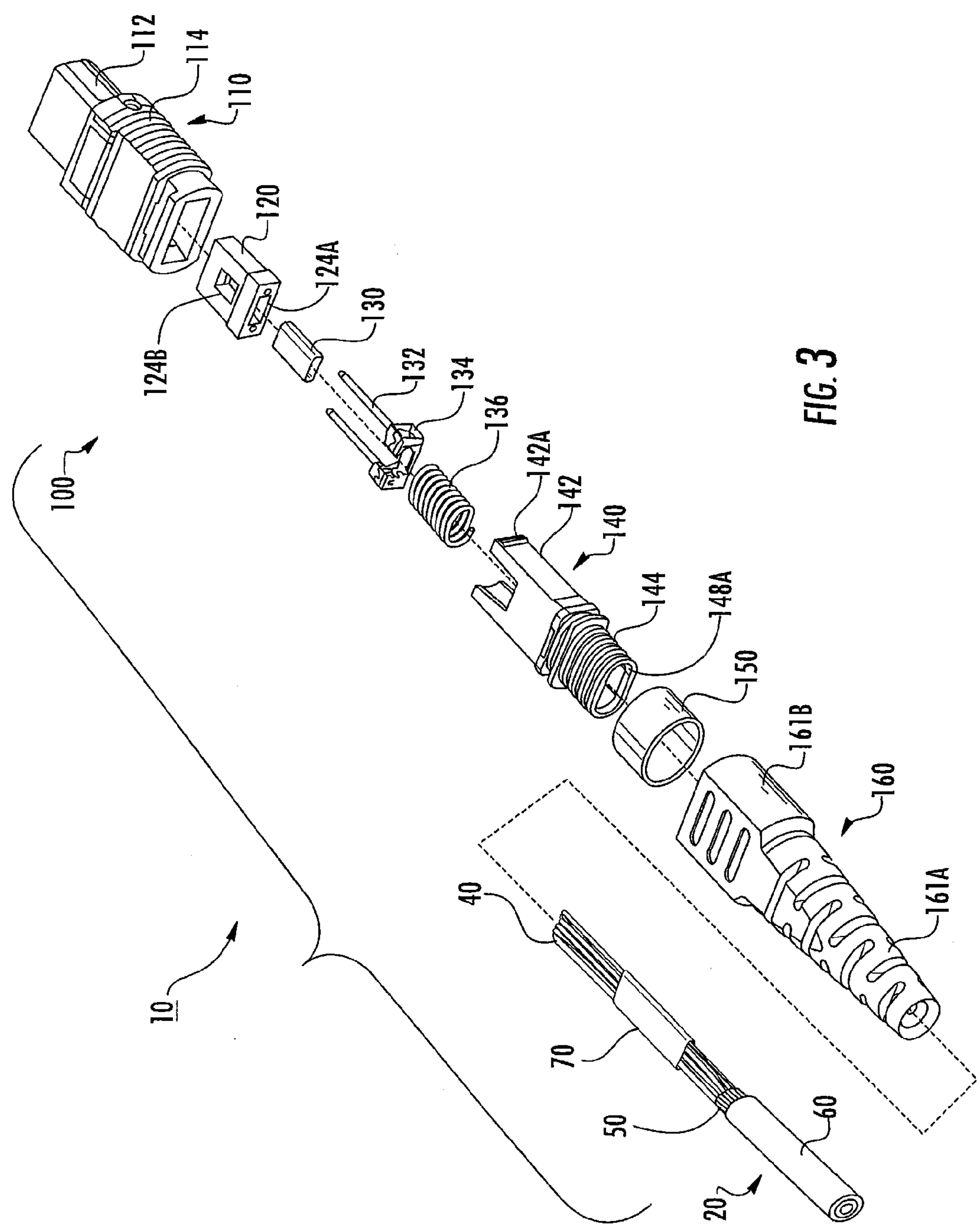
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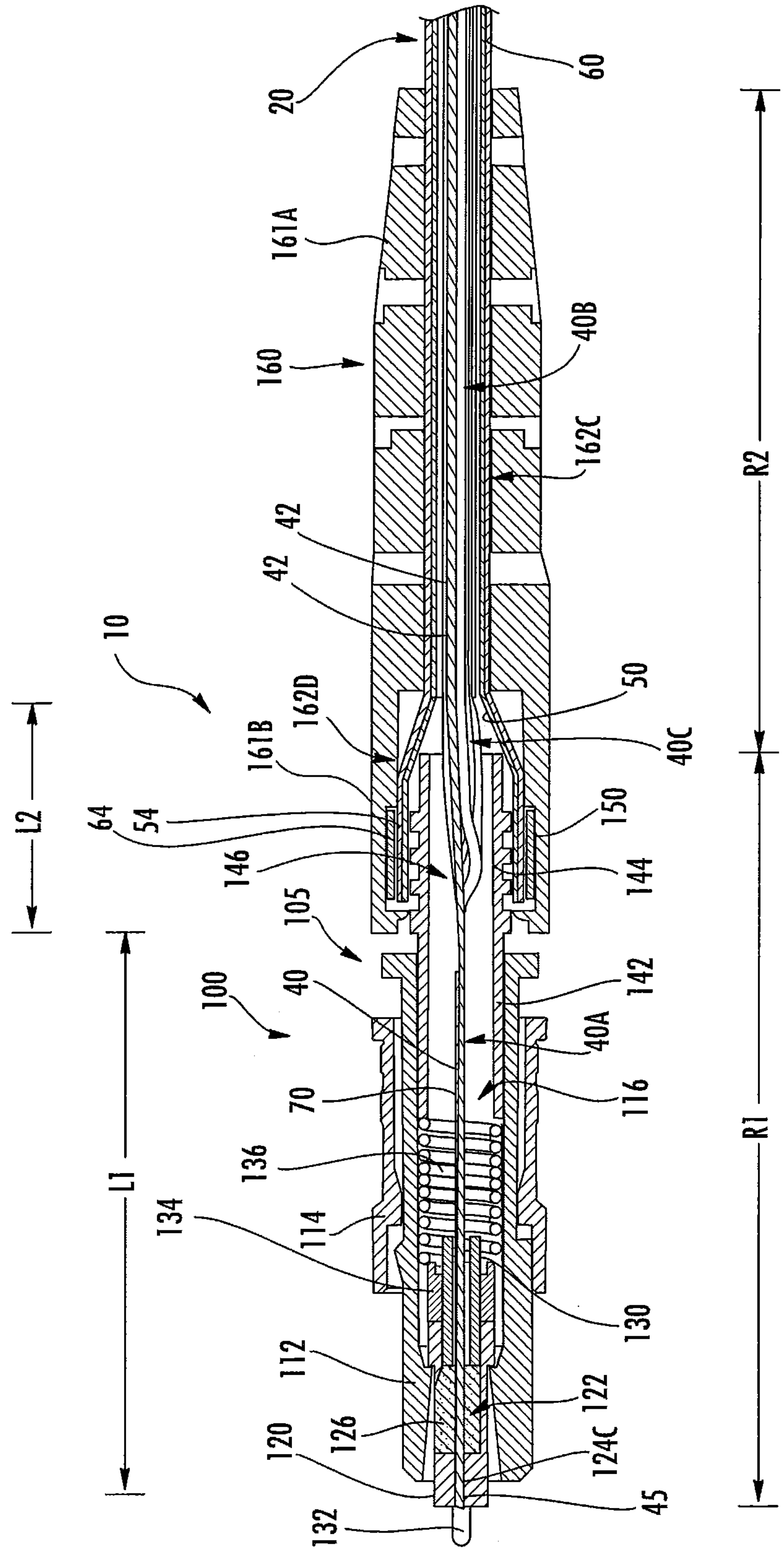
FIG. 3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144
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126
120
124C
45
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FIG. 4

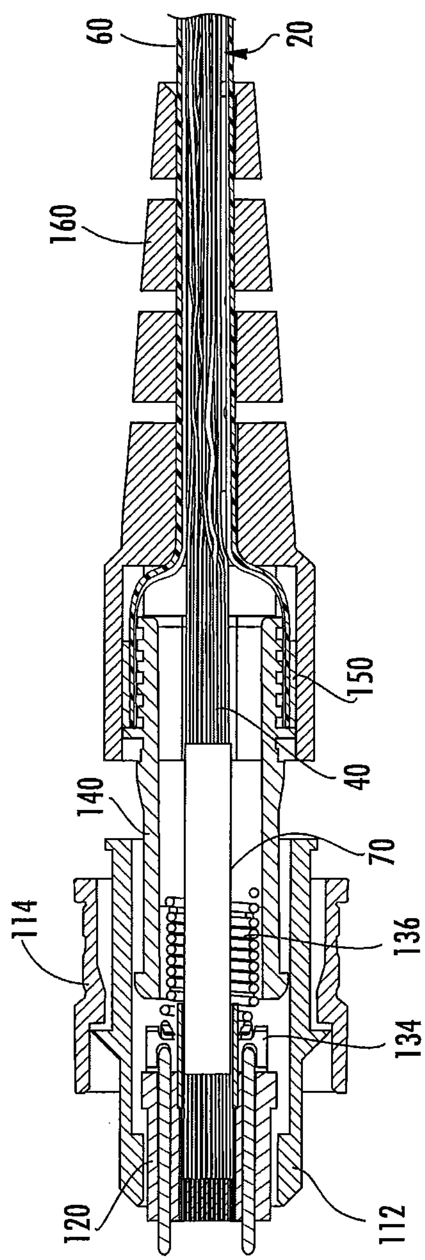

FIG. 5

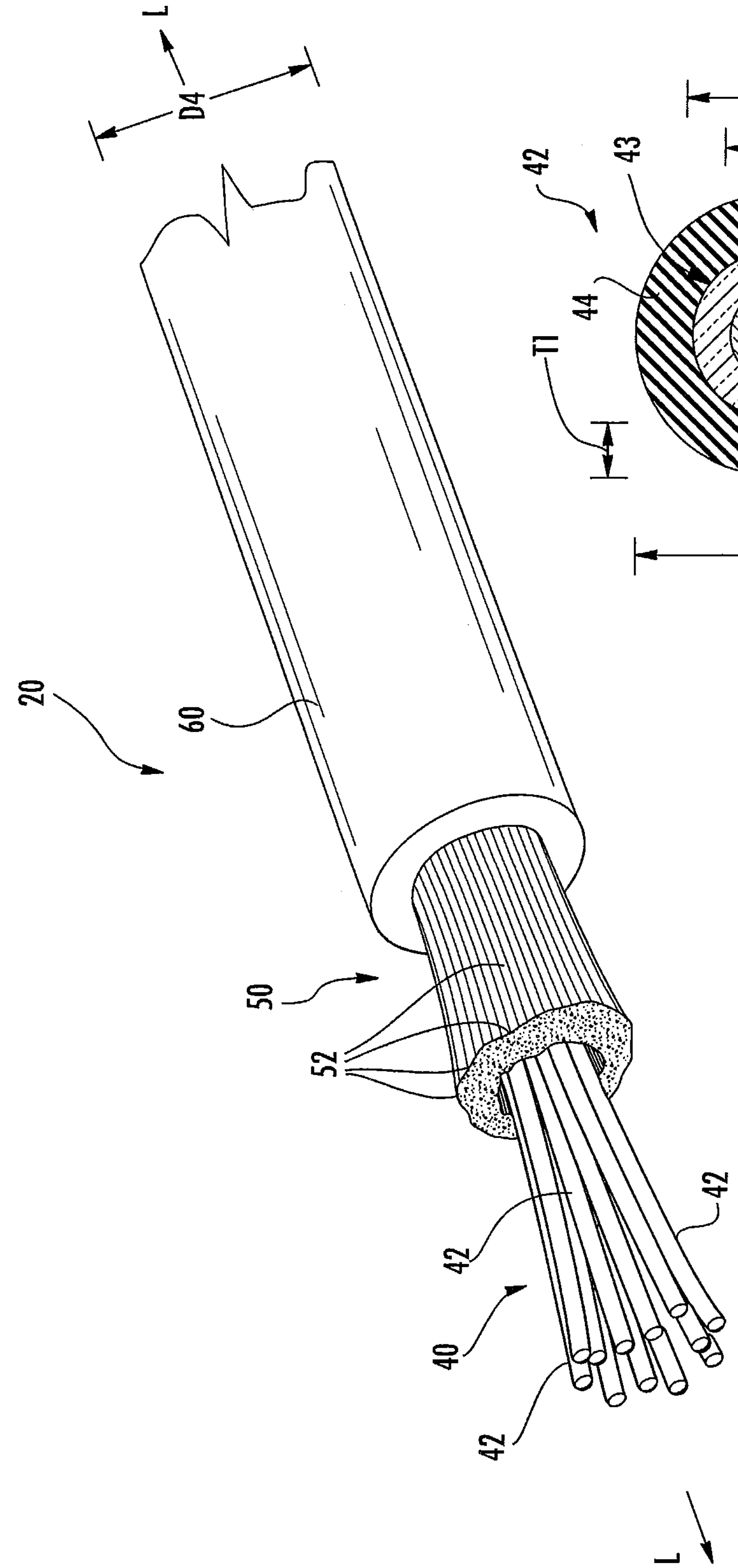

FIG. 6

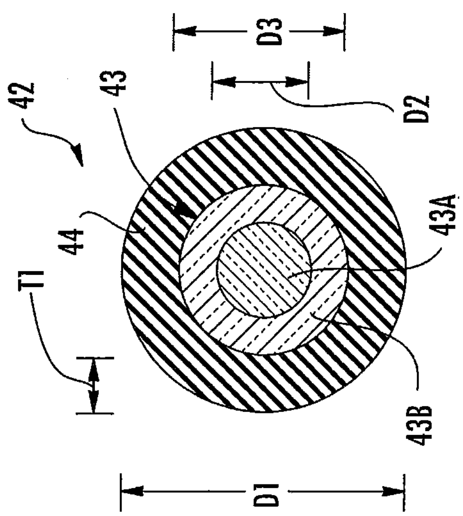

FIG. 7

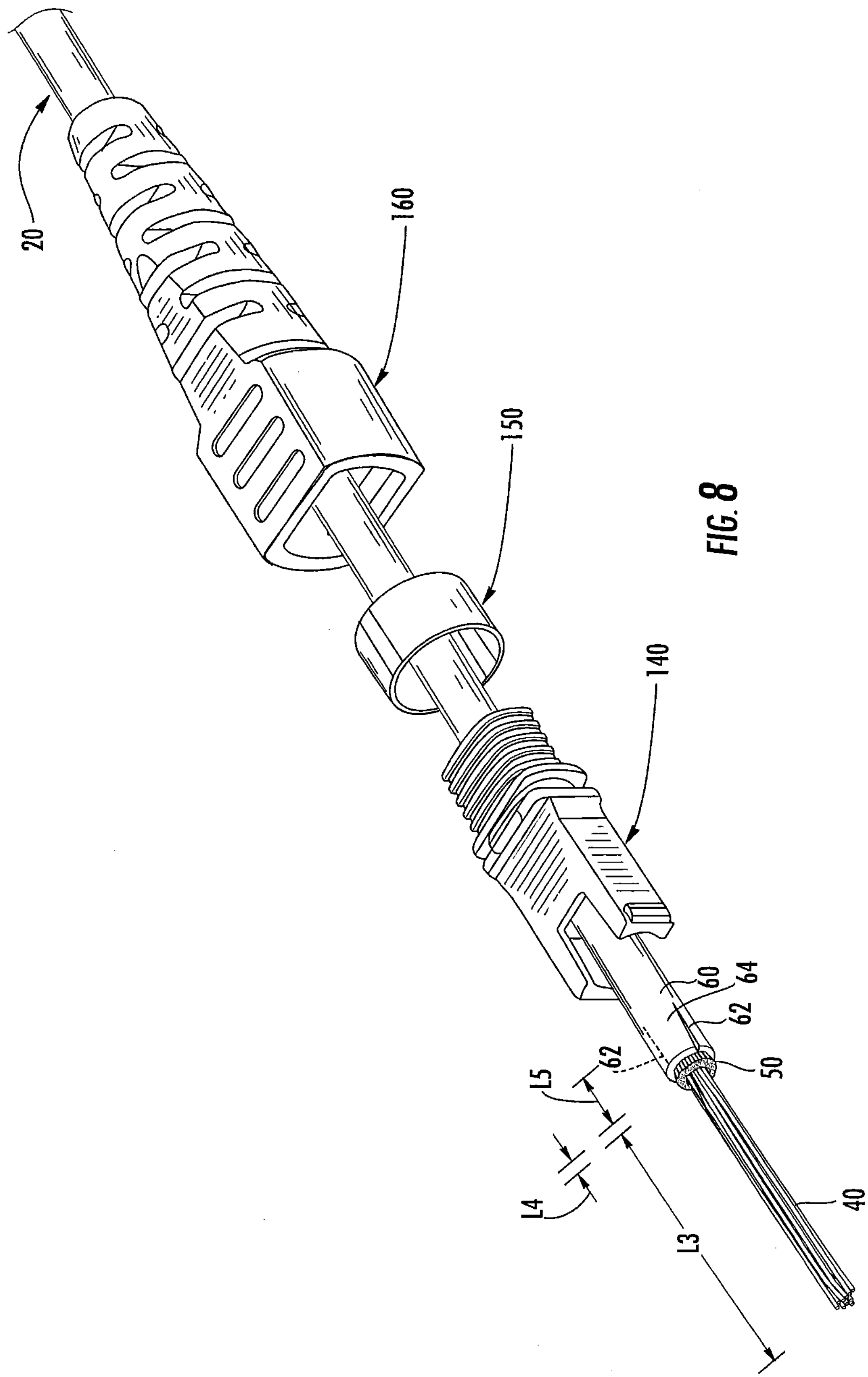

FIG. 8

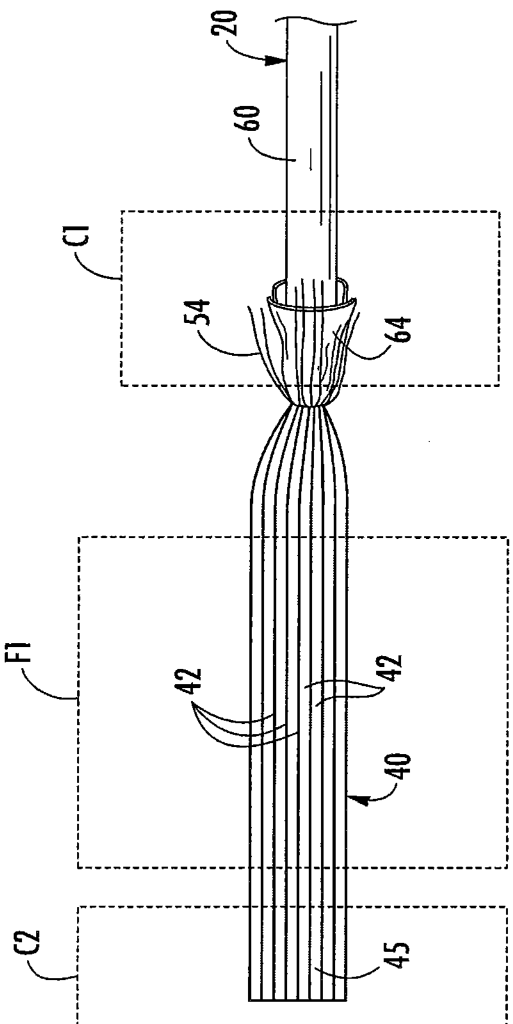

FIG. 9

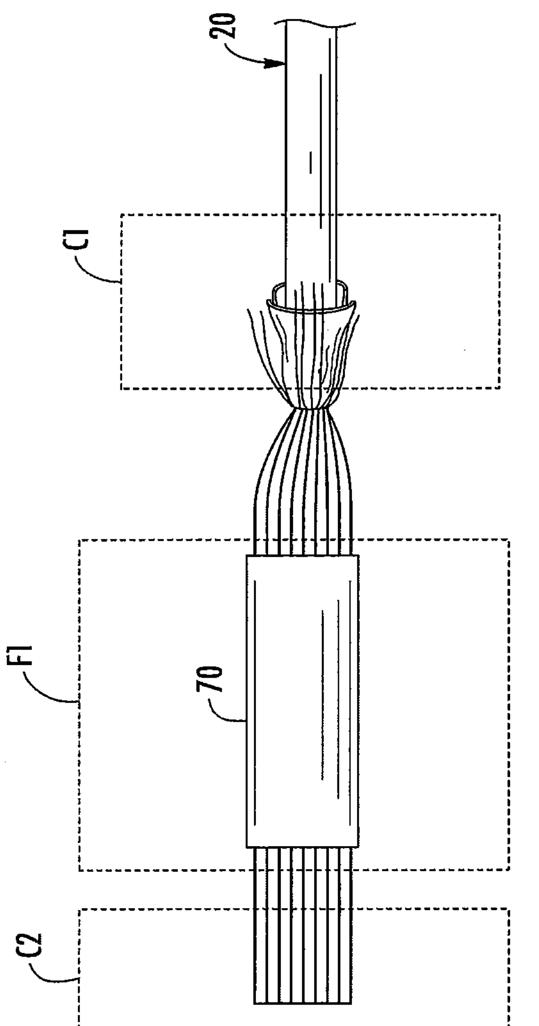

FIG. 10

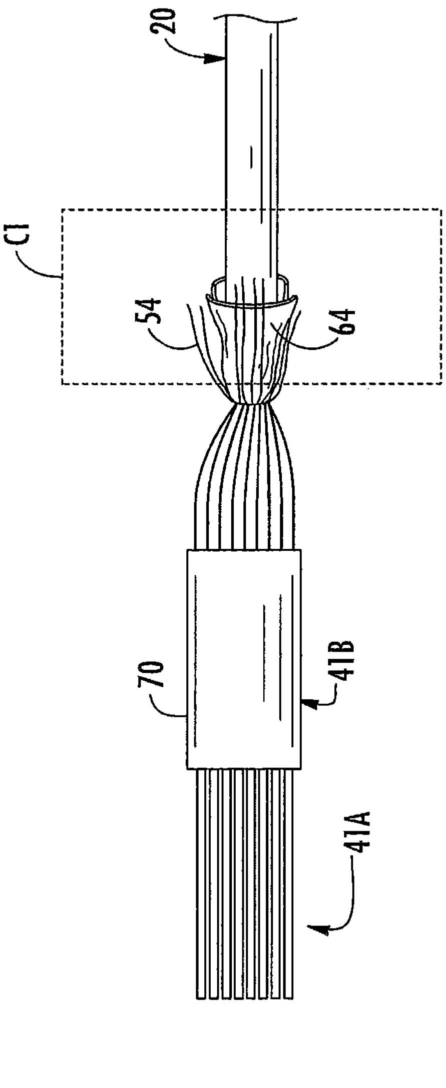

FIG. 11

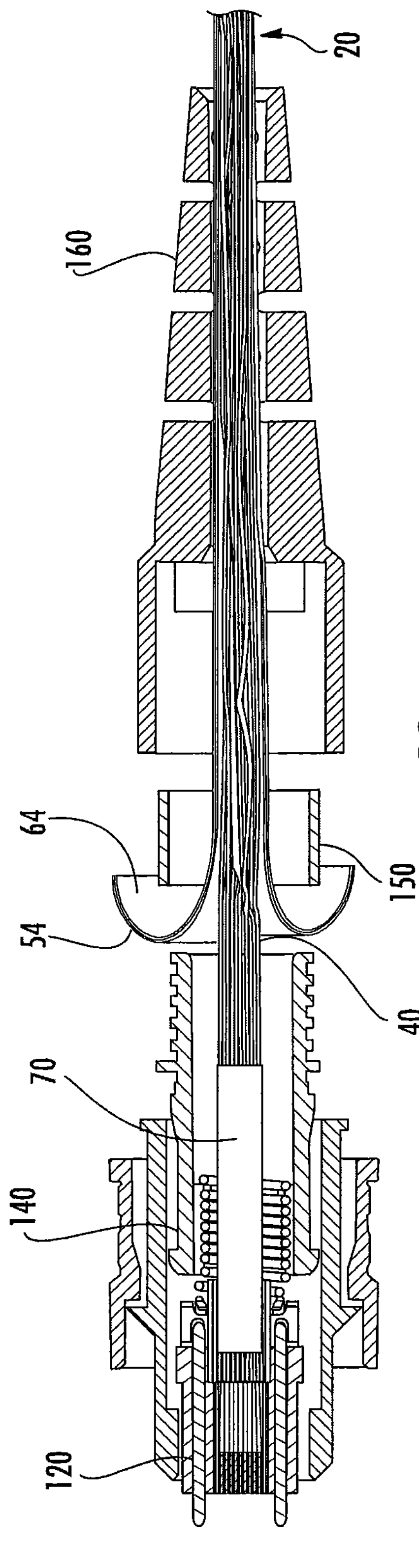

FIG. 12

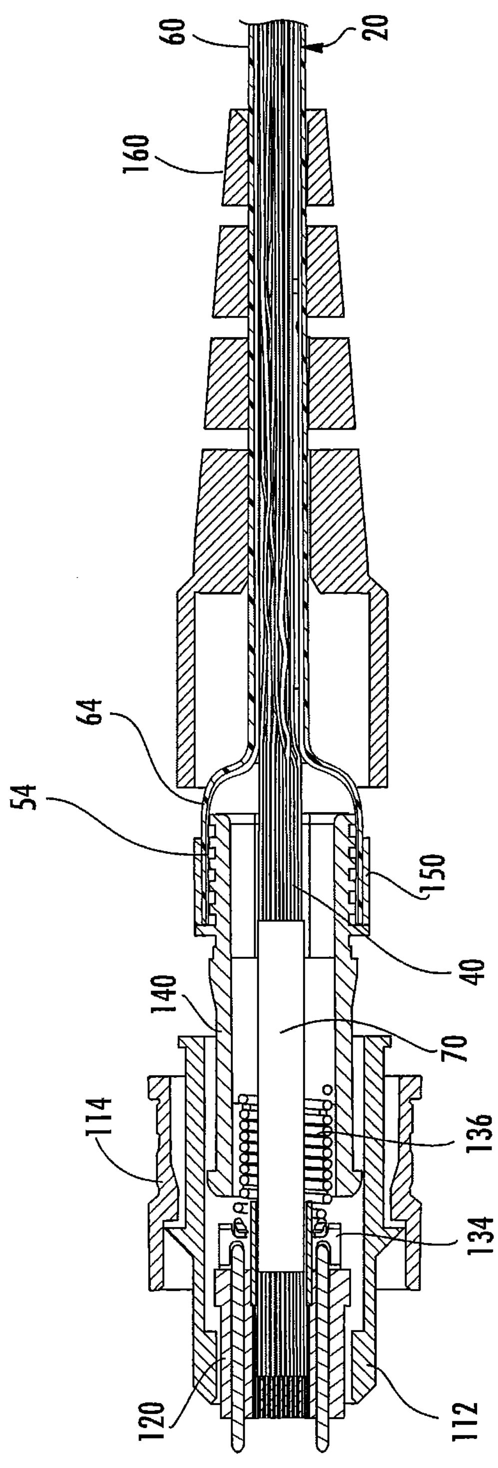

FIG. 13

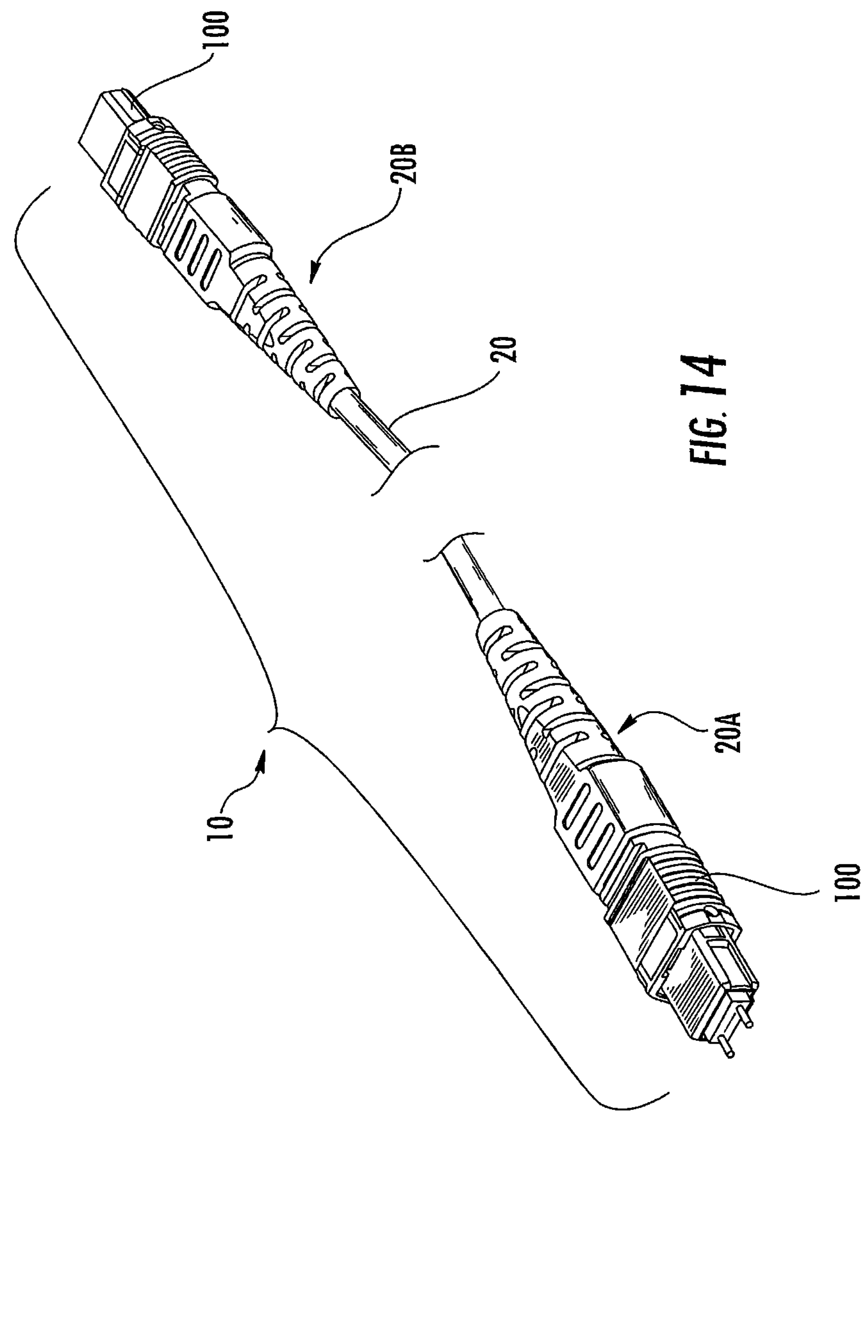

FIG. 14

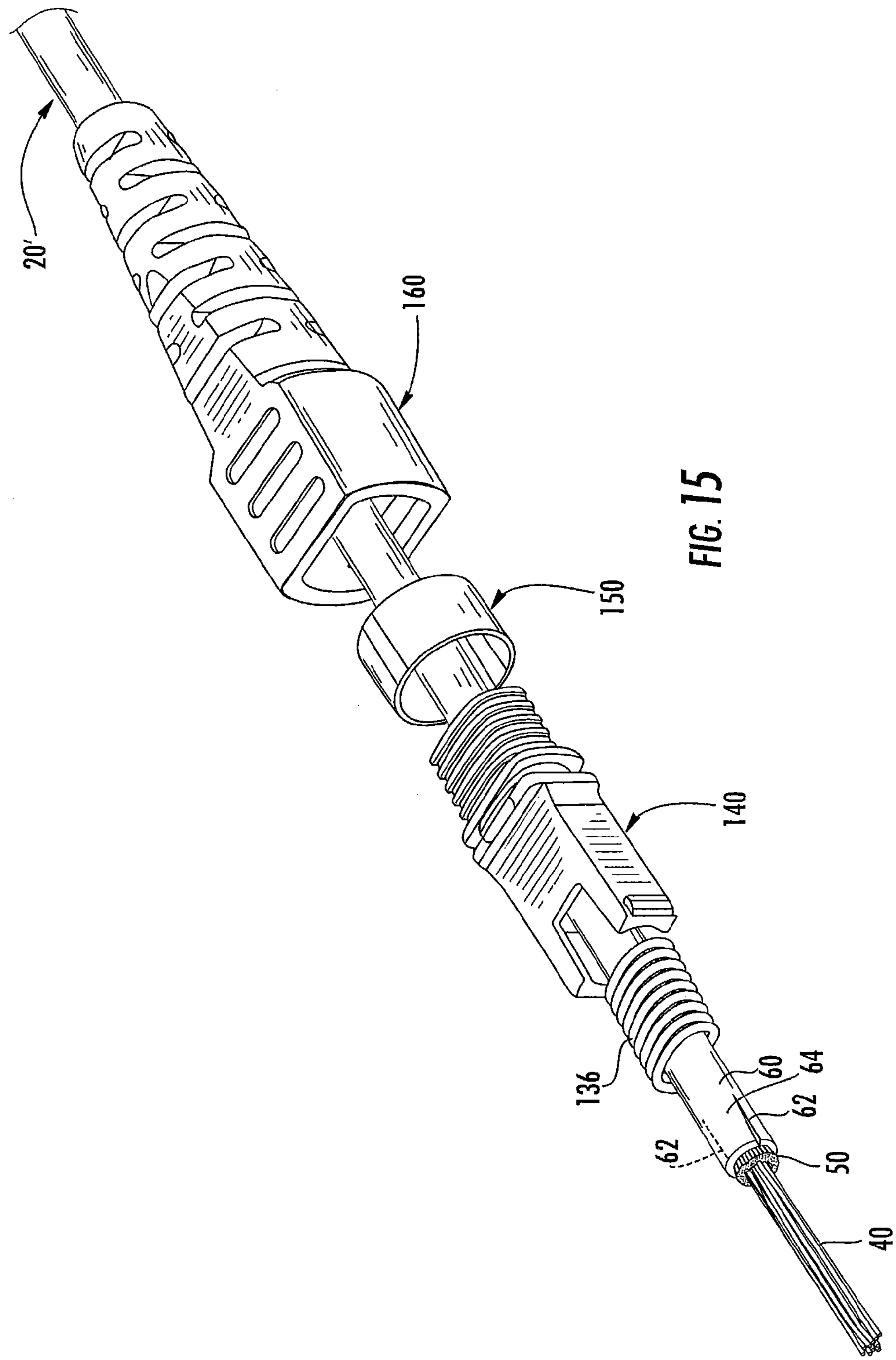

FIG. 15

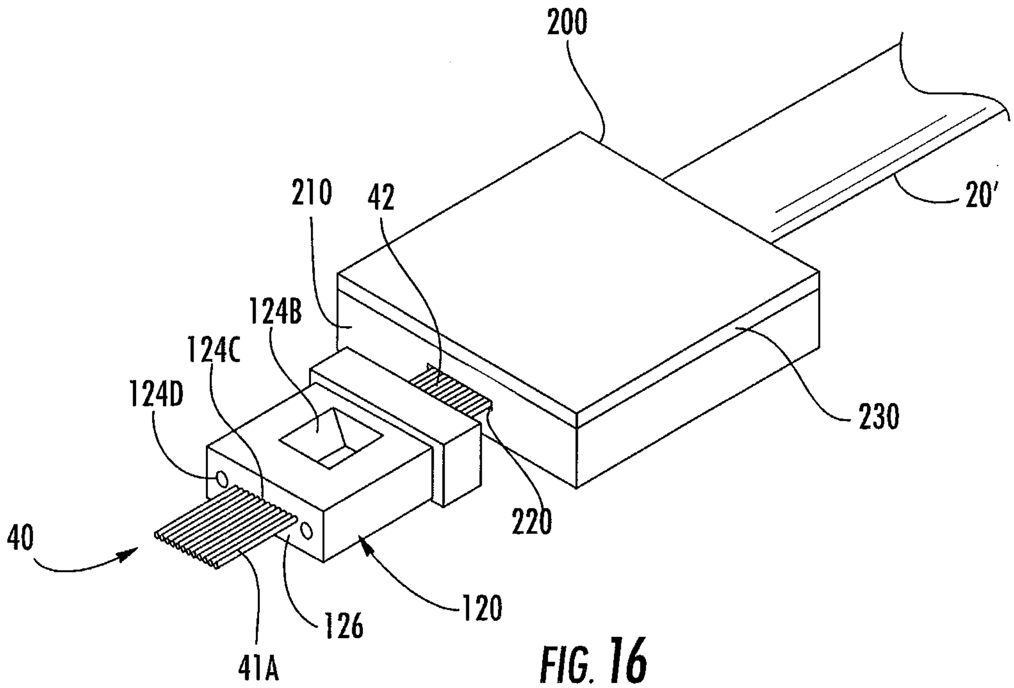

FIG. 16

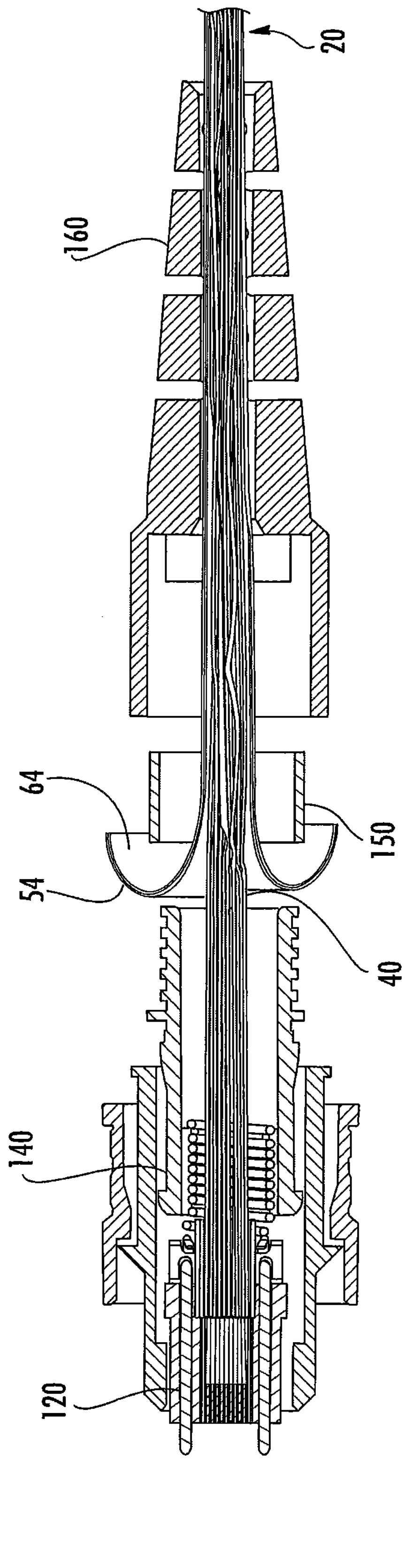

FIG. 17

METHODS FOR FORMING CONNNECTORIZED FIBER OPTIC CABLING

CLAIM OF PRIORITY

This application claims priority under 35 U.S.C. §120 as a continuation of U.S. patent application Ser. No. 12/818,586, filed Jun. 18, 2010, which is a continuation-in-part application of U.S. patent application Ser. No. 12/423,435, filed Apr. 14, 2009, now U.S. Pat. No. 7,758,257, which in turn is a continuation of U.S. patent application Ser. No. 11/438,647, filed May 22, 2006, now U.S. Pat. No. 7,537,393, which in turn claims the benefit of priority from U.S. Provisional Patent Application No. 60/688,492, filed Jun. 8, 2005, and U.S. Provisional Patent Application No. 60/688,493, filed Jun. 8, 2005. The disclosures of each of the above applications are incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates to communications cabling and, more particularly, to connectorized fiber optic cabling and methods for forming the same.

BACKGROUND OF THE INVENTION

Fiber array connectors are commonly employed to terminate multi-fiber fiber optic cables. Such connectors require that the fibers of the cable be arranged in a row or side-by-side, aligned configuration. In some cases, multiple, stacked layers or rows of fibers may be used. One method for providing fibers so arranged is to use ribbonized cabling. However, ribbonized cabling may suffer from drawbacks in bendability and cost. Another method is to use loose tube fiber cabling, ribbonize a relatively long section (e.g., from about 2 to 8 inches) of the fibers and install furcation tubing and other components on the cabling. This method using furcation tubing may suffer from various drawbacks in cost, bendability, installation requirements, etc. For example, epoxy typically must be used to secure a transition between the cable and the furcation tubing.

SUMMARY OF THE INVENTION

According to embodiments of the present invention, a connectorized fiber optic cabling assembly includes a loose tube fiber optic cable and a connector assembly. The cable has a termination end and includes: an optical fiber bundle including a plurality of optical fibers; at least one strength member; and a jacket surrounding the optical fiber bundle and the at least one strength member. The connector assembly includes a rigid portion and defines at least one fiber passage. The connector assembly is mounted on the termination end of the cable such that the optical fiber bundle extends through at least a portion of the at least one fiber passage. The plurality of optical fibers of the optical fiber bundle have a ribbonized configuration in the rigid portion of the connector assembly and a loose, non-ribbonized configuration outside the rigid portion. The plurality of optical fibers undergo a transition from the ribbonized configuration to the loose, non-ribbonized configuration in the rigid portion of the connector assembly. According to some embodiments, the rigid portion of the connector assembly includes a rigid connector housing.

According to method embodiments of the present invention, a method for forming a connectorized fiber optic cabling assembly includes providing a loose tube fiber optic cable having a termination end and including: an optical fiber

bundle including a plurality of optical fibers having a loose, non-ribbonized configuration; at least one strength member; and a jacket surrounding the optical fiber bundle and the at least one strength member. The method further includes mounting a connector assembly including a rigid portion and defining at least one fiber passage on the termination end of the cable such that the optical fiber bundle extends through at least a portion of the at least one fiber passage, and such that the plurality of optical fibers of the optical fiber bundle have a ribbonized configuration in the rigid portion of the connector assembly and a loose, non-ribbonized configuration outside the rigid portion, and the plurality of optical fibers undergo a transition from the ribbonized configuration to the loose, non-ribbonized configuration in the rigid portion of the connector assembly. According to some embodiments, the rigid portion of the connector assembly includes a rigid connector housing.

According to some embodiments, a connectorized fiber optic cabling assembly includes a loose tube fiber optic cable and a connector assembly. The loose tube fiber optic cable has a termination end and includes: an optical fiber bundle including a plurality of optical fibers; at least one strength member; and a jacket surrounding the optical fiber bundle and the at least one strength member. The connector assembly is mounted directly on the termination end of the cable. The plurality of optical fibers of the optical fiber bundle have a ribbonized configuration in the connector assembly and a loose, non-ribbonized configuration outside the connector assembly and in the cable. According to some embodiments, the cable is a round, loose tube cable.

According to some embodiments, a method for forming a connectorized fiber optic cabling assembly includes providing a loose tube fiber optic cable having a termination end and including: an optical fiber bundle including a plurality of optical fibers; at least one strength member; and a jacket surrounding the optical fiber bundle and the at least one strength member. The method further includes mounting a connector assembly directly on the termination end of the cable such that the plurality of optical fibers of the optical fiber bundle have a ribbonized configuration in the connector assembly and a loose, non-ribbonized configuration outside the connector assembly and in the cable. According to some embodiments, the cable is a round, loose tube cable.

Further features, advantages and details of the present invention will be appreciated by those of ordinary skill in the art from a reading of the figures and the detailed description of the preferred embodiments that follow, such description being merely illustrative of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front perspective view of a connectorized cabling in accordance with embodiments of the present invention.

FIG. **2** is a front exploded, perspective view of the connectorized cabling of FIG. **1**.

FIG. **3** is a rear exploded, perspective view of the connectorized cabling of FIG. **1**.

FIG. **4** is a cross-sectional view of the connectorized cabling of FIG. **1** taken along the line **4-4** of FIG. **1**.

FIG. **5** is a cross-sectional view of the connectorized cabling of FIG. **1** taken along the line **5-5** of FIG. **1**.

FIG. **6** is an enlarged, fragmentary view of a cable forming a part of the connectorized cabling of FIG. **1**.

FIG. **7** is a cross-sectional view of an optical fiber forming a part of the cable of FIG. **6**.

FIGS. **8-13** illustrate method steps for forming the connectorized cabling of FIG. **1** in accordance with method embodiments of the present invention.

FIG. **14** is a fragmentary, perspective view of a cordage in accordance with embodiments of the present invention.

FIGS. **15-17** illustrate method steps for forming a connectorized cable in accordance with further embodiments of the present invention

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. In the drawings, the relative sizes of regions or features may be exaggerated for clarity. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

It will be understood that when an element is referred to as being "coupled" or "connected" to another element, it can be directly coupled or connected to the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly coupled" or "directly connected" to another element, there are no intervening elements present.

In addition, spatially relative terms, such as "under", "below", "lower", "over", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. Thus, the exemplary term "under" can encompass both an orientation of over and under. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Like numbers refer to like elements throughout. As used herein the term "and/or" includes any and all combinations of one or more of the associated listed items.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

With reference to FIGS. **1-5**, a connectorized cabling or cordage assembly **10** according to embodiments of the present invention is shown therein. The connectorized cabling **10** includes a cable **20** and a connector assembly **100**. The connector assembly **100** may be an optical fiber array or multi-fiber push-on (MPO) type connector (which may also be referred to as an oval connector). The connector assembly **100** may be a plug connector as shown or, alternatively, a female jack connector with suitable modifications.

The cable **20** may be a breakout or subunit cable from a larger cable including multiple cable subunits and one or more additional jackets. According to some embodiments, the cable **20** is constructed as disclosed in co-assigned U.S. patent application Ser. No. 11/412,616, filed Apr. 27, 2006, entitled *Fiber Optic Cables and Methods for Forming the Same,* the disclosure of which is incorporated herein by reference.

As shown in FIG. **6**, the cable **20** includes generally a plurality of non-buffered optical fibers **42** (collectively forming a fiber bundle **40**), a plurality of strength members or yarns **52** (collectively forming a yarn bundle **50**), and a protective jacket **60**. According to some embodiments and as illustrated, the cable **20** is round in cross-section and the foregoing groups of components are substantially concentrically positioned about and extend together along a length axis L-L. According to some embodiments, the fiber bundle **40** includes at least eight (8) non-buffered optical fibers **42**. As shown, the fiber bundle **40** includes twelve (12) non-buffered optical fibers **42**. According to some embodiments, the optical fibers **110** are loose with respect to one another so that they have no particular, fixed relative orientation.

An exemplary one of the optical fibers **42** is shown in cross-section in FIG. **7**. The optical fiber **42** includes a glass fiber **43**, which includes a glass core **43**A and a surrounding glass cladding **43**B. The glass fiber **43** may be constructed in any suitable manner. For example, each of the core **43**A and the cladding **43**B may include one or more concentric segments or layers, may be doped, etc. The glass fiber **43** may be formed of any suitable materials and using any suitable methods. A coating layer **44** surrounds the cladding **43**B. The coating layer **44** provides environmental protection for the glass fiber **43**. As illustrated, the coating layer **44** consists of a single coating layer; however, multiple concentric layers may be applied to form the overall layer **44**. According to some embodiments, the coating layer **44** is formed of a UV light-cured acrylate. The coating layers **44** of the respective optical fibers **42** may have different colors for color-coding purposes.

According to some embodiments and as illustrated, the optical fiber **42** is an optical fiber constructed as commonly referred to as a "bare optical fiber" or a "non-buffered optical fiber". According to some embodiments, the overall diameter D**1** of the optical fiber **42** is in the range of from about 235 to 265 μm. According to some embodiments, the thickness T**1** of the coating layer **44** is no greater than about 70.5 μm. According to some embodiments, the overall diameter D**1** is between about 235 to 265 μm and the thickness T**1** of the coating layer **44** is no greater than about 70.5 μm. According to some embodiments, the diameter D**2** of the core **43**A is between about 6 and 64 μm and the diameter D**3** of the cladding **43**B is between about 115 and 135 μm.

As shown, the bundle **50** of the strength yarns **52** at least partially surrounds the optical fiber bundle **40**. The strength yarns **52** may be formed of any suitable material. According to some embodiments, the strength yarns **52** are aramid fibers. Other suitable materials may include fiberglass or polyester. According to some embodiments, the strength yarns **52** each have a denier in the range of from about 250 to 3000. According to some embodiments, the strength yarn bundle **50** includes between about 2 and 10 ends or strands of the strength yarns **52** (which may each include hundreds of filaments).

The jacket **60** surrounds the yarn bundle **50** and the optical fiber bundle **40**, which reside in a longitudinal passage defined in the jacket **60**. The jacket **60** may be formed of any suitable material such as a polymeric material. According to some embodiments, the jacket **60** is formed of a thermoplastic polymer. According to some embodiments, the thickness of the jacket **60** is between about 0.20 and 1.0 mm. According to some embodiments, the outer diameter D4 (FIG. **6**) of the jacket **60** (i.e., the outer diameter of the cable **20**) is between about 2.75 and 3.25 mm and the cable **20** may be generally regarded as a 3.0 mm cable.

According to some embodiments, the inner diameter of the jacket passage is greater than the combined cross-sectional diameter of the optical fiber bundle **40** and the strength yarn bundle **50** so that at least the optical fibers **42** are loose and able to float within the jacket passage (i.e., move freely with respect to the jacket **60**). According to some embodiments, both the optical fibers **42** and the strength yarns **52** are loose and can float within the jacket passage (i.e., can move freely with respect to the jacket **60**). Thus, at least a portion of the volume of the jacket passage is not filled by the optical fibers **42** or the strength yarns **52** to allow movement of the optical fibers **42** and the strength yarns **52** within the jacket passage. The cable **20** may be referred to as a "round, loose tube cable". According to some embodiments, a non-round (e.g., oval) loose tube fiber optic cable can be employed instead.

The connector assembly **100** includes a connector housing **105**, a ferrule **120**, epoxy **128** (FIGS. **4** and **5**), a ferrule boot **130**, ferrule pins **132**, a pin retainer **134**, a spring **136**, a crimp sleeve **150**, and a strain relief boot **160**. The connector housing **105** includes a front housing **110** and a rear housing **140**. These components will be discussed in more detail below.

The front housing **110** includes an inner part **112** and an outer part **114** that are relatively slidable. A passage **116** extends through the front housing **110**. The passage **116** has a generally oval or rectangular lateral cross-section.

The front housing **110** is substantially rigid. The front housing **110** may be formed of any suitable material. According to some embodiments, the front housing **110** is formed of a thermoplastic. According to some embodiments, the front housing **110** is formed of a polymeric material such as polyethermide. According to some embodiments, the front housing **110** has a flexural modulus of at least about 2 GPa. The front housing **110** may be formed using any suitable method such as molding.

The ferrule **120** defines a cavity **122** and a rear opening **124**A and a top opening **124**B each communicating with the cavity **122**. Fiber holes **124**C and pin holes **124**D extend longitudinally through the ferrule **120**. The fiber holes **124**C are configured in side-by-side alignment across the width of the ferrule **120**. The ferrule **120** has a front face **126**. The ferrule **120** may be formed using any suitable materials and techniques. According to some embodiments, the ferrule **120** is formed of a polymeric material and, according to some embodiments, a composite material such as a glass filled polymer.

The ferrule boot **130** is tubular and may be formed of rubber. The ferrule pins **132**, the pin retainer **134**, the spring **136** and the crimp sleeve **150** may be formed of a suitable metal. The epoxy **128** may be a low stress thermal cure epoxy.

The rear housing **140** includes a front section **142** and a rear section **144**. A pair of opposed latch tabs **142**A extend laterally outwardly from the front section **142**. Ribs **144**A are formed on the rear section **144**. A passage **146** extends longitudinally through the rear housing **140** from a rear opening **148**A to a front opening **148**B. According to some embodiments, the passage **146** and the front openings **148**A, **148**B are generally oval or rectangular as shown.

The rear housing **140** is substantially rigid. The rear housing **140** may be formed of any suitable material. According to some embodiments, the rear housing **140** is formed of thermoplastic. According to some embodiments, the rear housing **140** is formed of a polymeric material such as polyethermide. According to some embodiments, the rear housing **140** has a flexural modulus of at least about 2 GPa. The rear housing **140** may be formed using any suitable technique, such as molding.

The strain relief boot **160** includes a rear section **161**A and a front section **161**B. A passage **162** extends longitudinally through the strain relief boot **160** from a rear opening **162**A to a front opening **162**B. The passage **162** has a generally cylindrical rear section **162**C and a generally oval or rectangular front section **162**D. Outer ribs **164** are formed on the rear section **161**A. Opposed top and bottom retention ribs **166** extend inwardly into the passage **162** adjacent the front opening **162**B.

The strain relief boot **160** may be formed of any suitable material. According to some embodiments, the strain relief boot **160** is formed of a polymeric material. According to some embodiments, the strain relief boot **160** is formed of thermoplastic, thermoplastic elastomer, or thermoplastic rubber. According to some embodiments, the strain relief boot **160** has a flexural modulus of between about 0.05 and 0.5 GPa and according to some embodiments, the flexural modulus may be higher with segmented strain relief designed to allow additional flex. The strain relief boot **160** may be formed using any suitable technique. According to some embodiments, the strain relief boot **160** is molded.

The fibers **42** extend through the fiber holes **124**C in the ferrule **120** such that fiber ends **45** are located at the front face **126** of the ferrule **120**. The fibers **42** are secured in the ferrule **120** by the epoxy **128**. The ferrule **120** is positioned in the front housing passage **116** such that a portion of the ferrule **120** extends forwardly of the front housing **110**. The rear housing **140** is coupled to the front housing **110** by the tabs **142**A such that the front section **142** is retained in the passage **116**. The ferrule boot **130** and the spring **136** surround the fibers **42**. The ferrule **120** is held in the passage **116** by the pin retainer **134**, which is held in place by the spring **136**, which is braced by the inner housing **140**. The pins **132** extend through the pin holes **124**D such that they protrude from the front face **126**. The pins **132** are also held in place by the pin retainer **134**.

The strength yarn bundle **50** and the jacket **60** are secured to the rear housing **140** by the crimp ring **150**. More particularly, segments of the yarn bundle **50** and the jacket **60** are captured between the rear section **144** of the rear housing **140** and the crimp sleeve **150**, which is crimped in place.

The strain relief boot **160** is secured to the rear housing **140** by the ribs **166**, which engage the front edge of the crimp sleeve **150**. The rear section **144** is positioned in the front passage section **162**D. A layer of tape **70** or adhesive may be present on the fiber bundle **40** within the front housing **110** and/or the rear housing **140** and/or a rear portion of the ferrule inside the epoxy **128**.

As shown in FIGS. **4** and **5**, the fiber bundle **40** extends from the front face **126**, through the front housing **110**, the ferrule **120**, the ferrule boot **130**, the spring **136**, the rear housing **140**, the crimp sleeve **150** and the strain relief boot **160**. The fiber bundle **40** has three segments or sections, as follows: a ribbonized fiber section **40**A, a non-ribbonized fiber section **40**B, and a fiber transition section **40**C between the sections **40**A and **40**B. In the ribbonized section **40**A, the fibers **42** are aligned in ordered, side-by-side relation with one another (which may be referred to as a "ribbon configuration"). According to some embodiments, the portions of the fibers **42** in the ribbonized section **40**A are disposed and extend generally in a single row or common plane as shown to provide a relatively wide, thin construction. In the non-ribbonized section **40**B, the fibers **42** are generally loose and disposed in various non-mutual planes. According to some embodiments, in the non-ribbonized section **40**B the fibers **42** have a generally round configuration. In the transition section **40**C, the fibers **42** are undergoing a transition (i.e., changing, converting, transforming or transiting) from the loose configuration to the ribbonized configuration.

According to some embodiments, the ribbonized section **40**A has a length L**1** (FIG. **4**) of at least about 5 mm. According to some embodiments, the length L**1** is between about 5 and 10 mm. According to some embodiments, the transition section **40**C has a length L**2** (FIG. **4**) of between about 20 and 30 mm.

With reference to FIGS. **4** and **5**, the connector assembly **100** has a fixed or rigid region or portion R**1** on the plug side and a strain relief or bendable region or portion R**2** on the cable side. In the portion R**1**, the connector assembly **100** prevents the segment of the cable **20** therein from being bent. According to some embodiments, the rigid portion R**1** may extend rearwardly beyond the rear opening of the housing **105**. In the portion R**2**, the connector assembly **100** may permit non-destructive bending of the cable **20**. In particular, in the rear section **161**A of the strain relief boot **160** (i.e., generally the portion having the ribs **164**), the strain relief boot **160** can be bent with decreasing amounts of strain relief and bend radius limitation from the rear housing **140** to the boot rear opening **162**A. The strain relief boot **160** may limit the cable bend angle to a gradual bend to thereby prevent or reduce bend related fiber breaks and/or performance losses. Thus, according to some embodiments, at least a portion of the strain relief boot **160** is semi-rigid to provide controlled fiber bend.

Termination of the connector assembly **100** on the cable **20** in accordance with embodiments of the present invention may be regarded as a round, loose tube fiber cable to array connector direct termination. The connector assembly **100** receives a round, loose tube fiber cable section and the fiber bundle of the round, loose cable section is converted or reconfigured to a ribbonized fiber bundle within the rigid portion R**1** of the connector assembly **100**. Thus, the entirety of the ribbonized fiber section **40**A is contained in the rigid portion R**1**. Thus, according to some embodiments, none of the ribbonized fiber bundle is located where it can be bent in use. This termination allows for the benefits of round, loose fiber cabling up to the connector termination. For example, as compared to ribbon cable or a cable furcation assembly, a round, loose cable segment may be easier to bend, may be bendable with less loss of cable performance, and may have less or no preferential bending limitations. Moreover, termination in accordance with embodiments of the present invention may obviate the need for furcation tubing and the related expense, mess and effort.

The strain relief boot passage **162** has a rear section **162**A that is round in cross-section (i.e., cylindrical) and properly sized to complement the round cable **20**. In this way, the strain relief boot **160** may properly engage the directly terminated round cable to provide suitable strain relief thereto.

According to some embodiments, the connectorized cabling **10** is a cabling or cordage as shown in FIG. **14** including a length of the cable **20** having a first termination end **20**A and a second opposing termination end **20**B, and a respective connector assembly **100** installed directly on either termination end **20**A, **20**B of the cable **20**. The two connector assemblies **100** may be configured the same or differently from one another. The optical fibers **42** extend from the termination end **20**A to the termination end **20**B. According to some embodiments, the strength yarns **52** are crimped or otherwise secured directly to both connector assemblies **100** as described herein. The strength yarns **52** extend continuously from one connector assembly **100** to the other and provide strain relief at both connector assemblies. According to some embodiments and as shown, the jacket **60** also extends continuously from and is directly secured to each connector assembly **100**.

Connectorized cables in accordance with embodiments of the present invention such as the connectorized cabling **10** may be formed using methods in accordance with embodiments of the present invention. According to some embodiments, the connectorized cable **10** can be assembled as follows.

The strain relief boot **160**, the crimp sleeve **150** and the rear housing **140** are slid onto the cable **20** and out of the way as shown in FIG. **8** (which is a front perspective view). The cable **20** is cut or trimmed such that a section of the strength member bundle **50** extends beyond the jacket **60** a length L**4**, and a section of the fiber bundle **40** extends beyond the strength yarn bundle **50** a length L**3**. According to some embodiments, the length L**3** is at least about 45 mm. According to some embodiments, the length L**4** is at least about 2 mm.

As also shown in FIG. **8**, the jacket **60** is longitudinally cut on opposed lateral sides to form opposed side slits **62** and opposed top and bottom jacket flaps **64**. According to some embodiments, the length L**5** of the slits **62** is at least about 13 mm. The jacket flaps **64** and end segments **54** of the yarns **52** are folded back onto the jacket **60** as shown in FIG. **9** and secured in place, for example, using a jacket clamp C**1**.

The fiber bundle **40** is then ribbonized using any suitable technique. According to some embodiments and with reference to FIG. **9** (which is a top view), the fibers **42** of the fiber bundle **40** are inserted into a fiber alignment tool or ribbonizing fixture F**1** such that the fibers **42** are properly relatively positioned and aligned. The fixture F**1** may be grooved or non-grooved. A fiber clamp C**2** may be applied to the free ends **45** of the fibers **42** to temporarily secure the fiber bundle **40** in the ribbonized configuration. Tape **70** (FIG. **10**) is applied to the ribbonized segment of the fiber bundle **40** to permanently or semi-permanently secure the segment in ribbonized configuration. Alternatively or additionally, a liquid adhesive or the like may be applied to the ribbonized segment of the fiber bundle **40**. Also, other types of fixtures may be employed to assist in ribbonizing the fiber bundle **40**. According to some embodiments, a Fujikura FAT-04 tool is used to apply an adhesive to the ribbonized fibers. According to some embodiments, the length of the gap between the rear edge of the ribbonizing tape **70** (or adhesive) and the base of the jacket flaps **64** is 15 mm or less.

With reference to FIG. **11** (which is a top view), the end section of the fiber bundle **40** is then stripped to remove the tape **70** or adhesive thereon and the fiber coating layer **44**. A thermal heat stripping tool such as a Fujiura HJS-02 Hot Jacket Stripper in conjunction with a Fujikura FH-12 modified to accommodate the round cable may be used to strip the fibers **42**. In this manner, a bare fiber section **41**A is formed extending from the fiber free ends **45** to a taped fiber section **41**B. The bare fiber section **41**A likewise has a ribbonized configuration.

With reference to FIG. **12**, the spring **136** and the ferrule boot **130** are slid onto the ribbonized fiber bundle **40**. The bare fibers of the fiber section **41**A are inserted into and through respective ferrule fiber holes **124**C. The epoxy **128** is injected or otherwise introduced into the ferrule cavity **122** through the top opening **124**B and cured to secure the fibers **42** in the fiber holes **124**C. Portions of the fibers **42** can then be cleaved and the front face **126** may be polished as needed. The ferrule pins **132** and the pin retainer **134** are installed on the ferrule **120**. The front housing **110** is mounted on the ferrule **120**. The spring **136** and the rear housing **140** are slid forward until the rear housing **140** latches with the front housing **110**.

With reference to FIG. **13**, the jacket flaps **64** and the end sections **54** of the strength yarns **52** are folded forward around the rear section **144** of the rear housing **140**. The crimp sleeve **150** is then slid forward over the jacket flaps **64**, the yarn end sections **54** and the rear housing rear section **144**. The crimp sleeve **150** is then crimped (e.g., using a suitable tool) to secure the jacket flaps **64** and the yarn ends **54** to the rear section **144**.

The strain relief boot **160** is then slid forward on the cable **20** until the retention tabs or ribs **166** engage the front edge of the crimp sleeve **150**.

According to some embodiments, the foregoing procedure is executed in a factory.

While a single layer ribbonized fiber section is provided in the illustrated embodiments, according to some embodiments, the ribbonized section may include multiple, stacked rows of the fibers in side-by-side alignment.

According to further embodiments of the present invention, methods of forming connectorized cables are provided in which a fiber optic cable **20'** is connectorized without the use of any tape (such as tape **70** of FIG. **10** above) or liquid adhesive. These methods are described below with reference to FIGS. **15-17**. These methods may be used to attach the connector assembly **100** described above to the fiber optic cable **20'**. The fiber optic cable **20'** may be identical to the fiber optic cable **20** described above, except that it does not include either the tape **70** or any liquid adhesive.

Referring to FIG. **15**, operations may begin by sliding the strain relief boot **160**, the crimp sleeve **150**, the rear housing **140** and the spring **136** onto the cable **20'** and out of the way. The cable **20'** may then be cut such that a section of the fiber bundle **40** extends beyond the both the strength yarn bundle **50** and the jacket **60**. The jacket **60** is longitudinally cut on opposed lateral sides to form opposed side slits **62** and opposed top and bottom jacket flaps **64**. The jacket flaps **64** and end segments of the strength yarn bundle **50** are then folded back onto the jacket **60** and may secured in place, for example, using a jacket clamp (not shown). In some embodiments of these methods, the use of this jacket clamp may not be necessary.

As shown in FIG. **16**, the fiber bundle **40** is then ribbonized using a fiber alignment tool **200** such that the fibers **42** are properly positioned and aligned. In some embodiments, the fiber alignment tool **200** may include a base **210** and a cap **230**. The base **210** may include a groove **220** that receives the fibers **42**. In some embodiments, a single groove **220** may be provided, while in other embodiments, individual grooves (not shown) may be provided for each of the fibers **42**. In still other embodiments, the groove **220** may be omitted, and other means (e.g., posts) may be used to facilitate properly positioning and aligning the fibers **42**. In some embodiments, the cap **230** may comprise a hinged cap. Additionally, magnets (not shown) may be included in either the base **210** or the cap **230**. These magnets may be used to hold the cap **230** in place on the base **210** once the fibers **42** have been inserted into the base **210** and properly positioned and aligned. The cap **230** holds the fibers **42** in their proper position and alignment within the base **210** with sufficient force such that the fibers **42** do not move relative to each other during normal handling, fiber coating stripping and connector assembly. As described below, the fiber alignment tool **200** may be removed once epoxy **128** is inserted into the ferrule boot **130** and cured.

As shown in FIG. **16**, the base **210** of the fiber alignment tool **200** is positioned under the exposed fibers **42** and under the end portion of the jacket **60** (in some embodiments the fiber alignment tool **200** need not be positioned under the jacket **60**). The fibers **42** are then positioned, for example, in the groove **220** in the base **210** of the fiber alignment tool **200**. The fibers **42** transition into a ribbonized configuration in the fiber alignment tool **200**, and are positioned in the proper order, but have a loose configuration behind the fiber alignment tool **200**. Next, the cap **230** is closed onto the base **210** such the fiber alignment tool **200** holds the ends of the fibers **42** in the ribbonized configuration.

Next, a thermal heat stripping tool (or other appropriate device) is used to strip the fiber coating layer **44** from the end sections of the fibers **42** that extend beyond the fiber alignment tool **200**. In this manner, a bare fiber section **41**A is formed that has a ribbonized configuration. In other embodiments, the ferrule boot **130** may be slid onto the fibers **42** (in the manner discussed below) before this stripping operation is performed.

With reference to FIGS. **16** and **17**, epoxy **128** is injected or otherwise introduced into the cavity **122** of ferrule **120** through the top opening **124**B. A vacuum may be used to draw the epoxy **128** through the ferrule **120**. The bare fiber section **41**A of the ribbonized fiber bundle **40** is then slid through the epoxy **128** and into the ferrule fiber hole **124**C (this is done while the fiber alignment tool **200** remains in place). The ferrule boot **130** is then pushed into the rear opening **124**A in the ferrule **120**. Next, the epoxy **128** is cured to secure the fibers **42** in the fiber hole **124**C. Once the epoxy **128** has been cured, the fiber alignment tool **200** may be removed. Portions of the fibers **42** can then be cleaved and the front face **126** of ferrule **120** may be polished as needed. The ferrule pins **132** and the pin retainer **134** may then be installed on the ferrule **120**, and the front housing **110** may be mounted on the ferrule **120** (see FIGS. **2-3**). The spring **136** and the rear housing **140** are slid forward until the rear housing **140** latches with the front housing **110**. Finally, the connectorized cable assembly may be completed by performing the crimping operations discussed above with respect to FIG. **13**. In some embodiments, the spring **136** may alternatively be placed over the fibers **42** in front of the split portion of the jacket **60** instead of being placed onto the cable **20'** in the manner discussed above with reference to FIG. **15**. In such embodiments, the alignment tool **200** may include a cutout portion (not shown) that receives the spring **136** during assembly of the ferrule **120**.

Pursuant to the above-described termination method, the fiber alignment tool **200** may be used to hold the fibers **42** in proper alignment until after the epoxy **128**, the bare fiber section **41**A and the ferrule boot **130** are inserted into the ferrule **120** and the epoxy **128** cured, thereby allowing the operation of adding a tape **70** or liquid adhesive to the exposed fibers **42** to be omitted. Here, the fibers **42** are in ribbonized configuration within the ferrule boot **130**, but have a loose fiber configuration immediately behind the ferrule boot **130**.

It will be appreciated that other configurations of connector assemblies may be employed. For example, the ferrule pins

132 may be omitted to form a female connector assembly for use with the male connector assembly **100** as illustrated. The pins **132** of the male connector assembly **100** may be received in the pin holes of the female connector assembly to facilitate alignment between the respective mating fiber ends. The male and female connector assemblies may be held together by an adapter, for example.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are intended to be included within the scope of the invention.

That which is claimed is:

1. A method for forming a connectorized fiber optic cabling assembly, the method comprising:

providing a loose tube fiber optic cable that includes an optical fiber bundle that has a plurality of optical fibers having a loose, non-ribbonized configuration, at least one strength member and a jacket surrounding the optical fiber bundle and the at least one strength member, wherein an end section of the optical fiber bundle extends beyond the strength member and the jacket;

receiving a portion of each optical fiber in a fiber alignment tool to align end portions of the optical fibers in a ribbonized configuration;

stripping a coating layer from the end of each of the optical fibers while the optical fibers are received in the fiber alignment tool;

inserting the ends of the optical fibers that are aligned in the ribbonized configuration within a fiber passage of a ferrule while the optical fibers are received in the fiber alignment tool; and then

removing the fiber alignment tool from the plurality of optical fibers.

2. The method of claim **1**, wherein the ends of the optical fibers are inserted into the fiber passage of the ferrule after the coating layer is stripped from the end section of each of the optical fibers.

3. The method of claim **1**, wherein stripping the a coating layer from the end of each of the optical fibers comprises using a thermal heat stripping tool to strip an environmental protection layer from the end of each optical fiber.

4. The method of claim **1**, further comprising:

introducing an epoxy into the ferrule;

curing the epoxy to secure the optical fibers in the ribbonized configuration within the ferrule.

5. The method of claim **4**, wherein the fiber alignment tool is removed from the optical fibers after the epoxy is cured.

6. The method of claim **4**, wherein a vacuum is used to draw the epoxy into the ferrule.

7. The method of claim **4**, wherein the epoxy is introduced into the ferrule before the ends of the optical fibers are inserted into the fiber passage of the ferrule.

8. The method of claim **1**, wherein receiving a portion of each optical fibers in the fiber alignment tool to align end portions of the optical fibers in the ribbonized configuration comprises:

opening a cap of the fiber alignment tool;

receiving the portions of the respective optical fibers in a base of the fiber alignment tool;

aligning the end portions of the optical fibers in the ribbonized configuration within the fiber alignment tool; and

closing the cap of the fiber alignment tool onto the base of the fiber alignment tool to hold the end portions of the optical fibers in the ribbonized configuration.

9. The method of claim **8**, wherein the base of the fiber alignment tool includes at least one groove.

10. The method of claim **8**, wherein at least one of the base and the cap of the fiber alignment tool includes magnets, and wherein the magnets hold the cap in place on the base.

11. The method of claim **1**, further comprising:

sliding a strain relief boot and a rear housing of a connector housing onto the loose tube fiber optic cable prior to receiving the portions of the respective optical fibers in the fiber alignment tool; and

connecting a front housing of the connector housing to the rear housing of the connector housing.

12. The method of claim **11**, further comprising securing at least one of the jacket and the strength member to the connector housing.

13. The method of claim **1**, wherein the connectorized fiber optic assembly includes the loose tube fiber optic cable and a connector housing that is mounted on an end of the fiber optic cable, wherein the connector housing includes:

a substantially rigid front housing;

a substantially rigid rear housing; and

a strain relief boot.

14. The method of claim **1**, further comprising sliding a ferrule boot onto the optical fibers before the ends of the optical fibers that are aligned in the ribbonized configuration are inserted within the fiber passage of the ferrule.

15. The method of claim **14**, wherein the ferrule boot is slid onto the optical fibers before the coating layer is stripped from the end of each of the optical fibers.

16. The method of claim **14**, wherein the ferrule boot is slid onto the optical fibers after the coating layer is stripped from the end of each of the optical fibers.

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